AMENDMENT

In the Specification:

Please amend the Specification to read as follows.

[0035] The external cavity laser 10 includes a grid generator element and a tunable element or channel selector, which are respectively shown in FIG. 1 as a grid etalon 24 and a wedge etalon 26 positioned in an optical path 22 between gain medium 12 and end mirror 14. Grid etalon is positioned in optical path 22 before tunable element 26, and has parallel reflective faces 28, 30. Grid etalon 24 operates as an interference filter, and the refractive index of grid etalon 24 and the optical thickness of grid etalon 24 as defined by the spacing of faces 28, 30 give rise to a multiplicity of transmission maxima within the communication band at wavelengths which coincide with the center wavelengths of a selected wavelength grid which may comprise, for example, the ITU (International Telecommunications Union) grid. Other wavelength grids may alternatively be selected. Grid etalon 24 has a free spectral range (FSR) that corresponds to the spacing between the grid lines of the ITU grid, and the grid etalon 24 thus operates to provide a plurality of passbands centered on each of the gridlines of the wavelength grid. Grid etalon 24 has finesse (free spectral range divided by full width half maximum or FWHM) that suppresses neighboring modes of the external cavity laser between each channel of the wavelength grid, as discussed further below.

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[0036] Grid etalon may be a parallel plate solid, liquid or gas spaced etalon, and may be tuned by precise dimensioning of the optical thickness between faces 28, 30 by thermal expansion and contraction via temperature control. The grid etalon 24 may alternatively be tuned by tilting to vary the optical thickness between faces 28, 30, by application of an electric field to an electro-optic etalon material, by changing the pressure of a gas spaced etalon, by inducing an index change in a nonlinear optical material with a second optical beam, or by changing the size of a spacer that determines the spacing in a gas or liquid filled etalon by thermal, piezoelectric, or

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micromechanical means. Grid etalon 24 alternatively may be actively tuned during laser operation as described in the U.S. Patent Application Ser. No. 09/900,474 entitled "External Cavity Laser with Continuous Tuning of Grid Generator" to inventor Andrew Daiber, co-filed herewith, and incorporated herein by reference.

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[0038] Wedge etalon 26 as shown in FIG. 1 is only one tunable element or channel selector that may be used in accordance with the invention in an external cavity laser, and various other types of channel selector may be used in place thereof, including grating, electro-optic, thin film and vernier tuning devices. The use of an air gap wedge etalon for channel selection is described in U.S. Patent No. 6,108,355, wherein the "wedge" is a tapered air gap defined by adjacent substrates. The use of pivotally adjustable grating devices as channel selectors tuned by grating angle adjustment and the use of an electro-optic tunable channel selector in an external cavity laser and tuned by selective application of voltage are described in U.S. Patent Application Ser. No. 09/814,646 to inventor Andrew Daiber and filed on March 21, 2001. The use of a translationally tuned graded thin film interference filter as a channel selector is described in U.S. Patent Application Ser. No. 09/814,646 and in U.S. Patent Application Ser. No. 09/900,412 entitled "Graded Thin Film Wedge Interference Filter and Method of Use for Laser Tuning" to inventors Hopkins et al., co-filed herewith. The aforementioned disclosures are incorporated herein by reference.

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[0046] The external cavity defined by end mirror 14 and output facet 18 is tunable by an external cavity tuner or drive mechanism 46. In the embodiment shown, external cavity drive 46 is operatively coupled to end mirror 14 and is configured to adjust the optical path length l of the external cavity by positionally adjusting end mirror 14. In other embodiments, the external cavity drive 46 may be operately coupled to gain medium 12 and configured to positionally adjust gain medium 12 to tune the external cavity or to thermally adjust the optical path length of the gain medium 12 to tune the external cavity. In still other embodiments, external cavity drive 46 may by electro-optic in nature and carry out adjustment of optical path length l by changing the effective optical thickness of an electro-optic tuner (not shown) in the external cavity, as

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described further below. Electro-optic tuning of an external cavity is disclosed in U.S. Patent Application Ser. No. 09/900,426 entitled "Evaluation and Adjustment of Laser Losses According to Voltage Across Gain Medium" to inventors Daiber et al., the disclosure of which is incorporated herein by reference. Various mechanisms for tuning the optical path length *l* may be used with the invention, and the wavelength tuning will be configured accordingly to provide adjustment of optical path length *l*.

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[0047] In certain embodiments, external cavity drive 46 may comprise a thermally tunable compensator element (not shown) that is configured to position end mirror 14 by heating or cooling the thermal compensator element according to optical cavity adjustment signals from external cavity controller 48 to a thermoelectric controller (also not shown) coupled to the thermally tunable compensator element. The use of a thermally controlled tuning element to positionally adjust and end mirror and other optical components in an external cavity laser is also described in U.S. Patent Application Ser. No. 09/814,646 to inventor Andrew Daiber, filed on March 21, 2001, and in U.S. Patent Application Ser. No. 09/900,443 entitled "Laser Apparatus with Active Thermal Tuning of External Cavity" to inventors Mark Rice et al., which is co-filed simultaneously herewith.

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[0048] External cavity drive 46 is operatively coupled to an external cavity controller 48 which provides signals to control the positioning of end mirror 14 by external cavity drive 46. External cavity controller 46 may be operatively coupled to a voltage sensor 50, which in turn is operatively coupled to one of a pair of electrodes 52, 54 associated with gain medium 12. Electrodes 52, 54 provide a drive current to gain medium 12 from drive current source 56. Since optical feedback from end mirror 14 enters gain medium 12 through anti-reflection coated front facet 16, voltage across gain medium 12 as monitored by sensor 50 accurately indicates losses associated with the external cavity. External cavity controller 48 is configured to generate cavity mode signals from the output of voltage sensor 50, and to provide compensating signals to external cavity drive 46. The use of monitoring voltage modulation across a gain medium in an external cavity laser to evaluate external cavity losses and generate error signals therefrom is also

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described in U.S. Patent Application Ser. No. 09/900,426 entitled "Evaluation and Adjustment of Laser Losses According to Voltage Across Gain Medium" to inventors Daiber et al., the disclosure of which is incorporated herein by reference.

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[0049] External cavity controller 48 may alternatively, or additionally, include stored lookup tables of optical cavity tuning information that provides positions corresponding to selectable optical path lengths *l*. External cavity controller 48 may be internal to external cavity drive 46, or may be external and shared in other component positioning and servo functions of the external cavity laser 10. External cavity controller 46 may, in certain instances, be embodied in the same controller device as wavelength controller 36 described above. An encoder 60 may be included in association with external cavity drive 46 to ensure correct positioning or adjustment thereof by external cavity controller 48.

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[0057] The passbands PB1 defined by the external cavity longitudinal modes are omitted from FIG. 3A-3C for reason of clarity. As discussed previously, the laser will lase on the cavity mode with the highest round trip transmission through the cavity. In FIG. 3A, passband PB2 has the greatest transmission, and a laser mode close to the peak of PB2 will have the greatest overall transmission through the external cavity. By placing a small dither or frequency modulation on the optical path length of the cavity, an error signal may be generated which usable to adjust the (mean) optical path length of the cavity so that the laser mode is locked to the peak of passband PB2 with the greatest transmission through passband PB3. It is also useful to place a small dither or frequency modulation on the location of passband PB3 to lock the peak of passband PB3 to the lasing mode, itself locked to a peak of passband PB2. The use of dither or modulation elements to introduce frequency modulation into laser components is described in U.S. Patent Application ser. No. 09/900,426 entitled "Evaluation and Adjustment of Laser Losses According to Voltage Across Gain Medium" to inventors Daiber et al., noted above and incorporated herein by reference.

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[0063] Equal changes in the length of actuators 62, 64 translate grating 60 along beam 22 to change the optical path length l (defined by grating 60 and gain medium facet 18) without tuning the grating 60 to affect wavelength. Changing the length of actuators 62, 64 with equal magnitudes but in opposite directions pivots grating 60 with respect to point 62 to change the tuning of grating 60 without changing the optical path length l of the external cavity. The tuning of the passband of grating 60 is thus independent or uncoupled from tuning of the optical path length, and the tuning of the optical path length is likewise independent or uncoupled from the tuning of the passband of grating 60. This orthogonal tuning of the grating passband and cavity optical path length is achieved using the same actuators 62, 64 together, but in different ways to achieve the different tunings. A grid generator is not shown with the external cavity laser 58, but may be included therewith.

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[0067] Second electro-optic tuning element 114 includes a layer 120 of lithium niobate or other electro-optic material positioned between transparent electrodes 122, 124. External cavity controller 116 is configured to apply an adjustable voltage to one of electrodes 122, 124, the other of which is suitably grounded. Second electro-optic tuning element 114 is configured such that adjustment of voltage across the electro-optic material of tuning element 114, while changing the effective optical thickness of tuning element 114, also adjusts the overall optical path length l across the external cavity (between diode facet 18 and end mirror 14). The use of an electro-optic element for external cavity tuning is also described in U.S. Patent Application Ser. No. 09/900,426 entitled "Evaluation and Adjustment of Laser Losses According to Voltage Across Gain Medium" to inventors Daiber et al., noted above and incorporated herein by reference.

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[0069] The second electro-optic tuning element 116 may also be used to introduce a signal modulation in the form of a frequency dither into the optical path length l of the external cavity laser. The signal modulation may comprise, for example, a frequency modulation of about 20kHz. Modulation of the optical path length l via frequency dither introduced by element 116 produces intensity variations in the output power of external cavity laser 98 which are detectable

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by photodetector 118 (or by monitoring voltage across gain medium 12 due to optical feedback thereinto from the external cavity). These intensity variations will vary in magnitude and phase error according to alignment of an external cavity mode with the center wavelength of the passbands defined by electro-optic tuning element 100 and grid generator 24. In other words, the intensity variations and phase shift in the modulation signal provide and effective way to evaluate external cavity losses and develop corresponding error signals for the adjustment of external cavity optical path length. Thus, external cavity controller 116 derives error signals from the modulation introduced by the frequency either, and communicates compensation signals to external cavity controller 116, which correspondingly adjusts the voltage applied across electro-optic substrate 120 to tune or adjust the optical path length *l* by changing the refractive index of substrate 120. The use of modulation elements to introduce frequency modulation or dither into laser components is described in U. S. Patent Application Ser. No. 09/900,426 entitled "Evaluation and Adjustment of Laser Losses According to Voltage Across Gain Medium" to inventors Daiber et al., noted above and incorporated herein by reference.

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